International Journal of Agricultural
Science and Research (IJASR)
ISSN (P): 2250-0057; ISSN (E): 2321-0087
Vol. 12, Issue 1, Jun 2022, 97–108

TRANS STELLAR
•Journal Publications •Research Consultancy

INDIAN SOYBEAN: THE WONDERCROP

DR. JOLLY MASIH[1], DR. ANIL BAJPAI[2] & DAMANDEEP KAUR[3]

[1]*Associate Prof., Prestige Institute of Engineering Management & Research*

[2]*Chief Operating Officer and Director at Prestige University Project*

[3] *Senior Data Scientist., Dada Analtix Pvt Ltd*

ABSTRACT

Since independence, India has achieved high production standards in pulses and sugarcane, which has helped in reducing the dependency on foreign imports. Such self- sufficiency in domestic production of local Indian varieties of oilseeds such as Soybean is need of an hour to safeguard the interest of Indian farmers, processors and to ensure better nutrition status of Indian citizens. In the last ten years, the yield and productivity of most oilseed crops has decreased by 10-30%, prompting anxiety about the quickly changing situation. This situation could end up posing a major threat to national health and food security. In the case of soybeans, the average area harvested has increased by 12% during 2010-11. However, production and productivity have both decreased by 7% and 31%, respectively. Soybean oil production is expected to decrease in 2021, according to a trend analysis of edible oil. Last year, the effect of the Covid-19 epidemic, inadequate rains, and unfavourable weather conditions resulted in a loss of soybean seed output and a reduction in soybean oil extraction, resulting in a gap. However, due to its numerous health benefits and high nutritional content, soybean oil demand in national and worldwide markets continues to expand dramatically year after year. Non-GMO Soybean is now attracting a lot of attention owing to growing consumer dissent against GM Soybean. The rising consumer awareness regarding labelling regulations and the quality of products is expected to drive market demand over the forecast period. Premiums for non-GMO soybeans have likewise witnessed exponential growth rates, implying that the market will expand rapidly. Madhya Pradesh is renowned as India's "Soybean State," accounting for 55 per cent of the country's total soybean farming area. Government involvement is urgently needed to protect the interests of soybean growers and processors. It could only be done by promoting non-GMO Indian soybeans on national and international markets, decreasing soymeal imports (to encourage indigenous soybean processors), and raising import tariffs on soymeal and soy oil to help local processors and industries.

KEYWORDS: Soybean, Production, Non-GMO Soybean, Food security

Received: Feb 01, 2022; **Accepted**: Feb 21, 2022; **Published**: Feb 26, 2022; **Paper Id.**: IJASRJUN202210

Original Article

1 INTRODUCTION

1.1. Series of Food Revolution to Make ‘Atmanirbhar’ for Food

Since independence, India has achieved self-sufficiency in major food grains including wheat and rice through the Green Revolution in 1960s. The league was then followed by White Revolution (1970s) for milk and dairy and Yellow Revolution (1980s) for oilseeds. India has also achieved high production standards in pulses and sugarcane, which has helped in reducing the dependency on foreign imports (see Figure 1). Such self- sufficiency in domestic production of local Indian varieties of oilseeds such as Soybean is need of an hour to safeguard the interest of Indian farmers, processors and to ensure better nutrition status of Indian citizens.

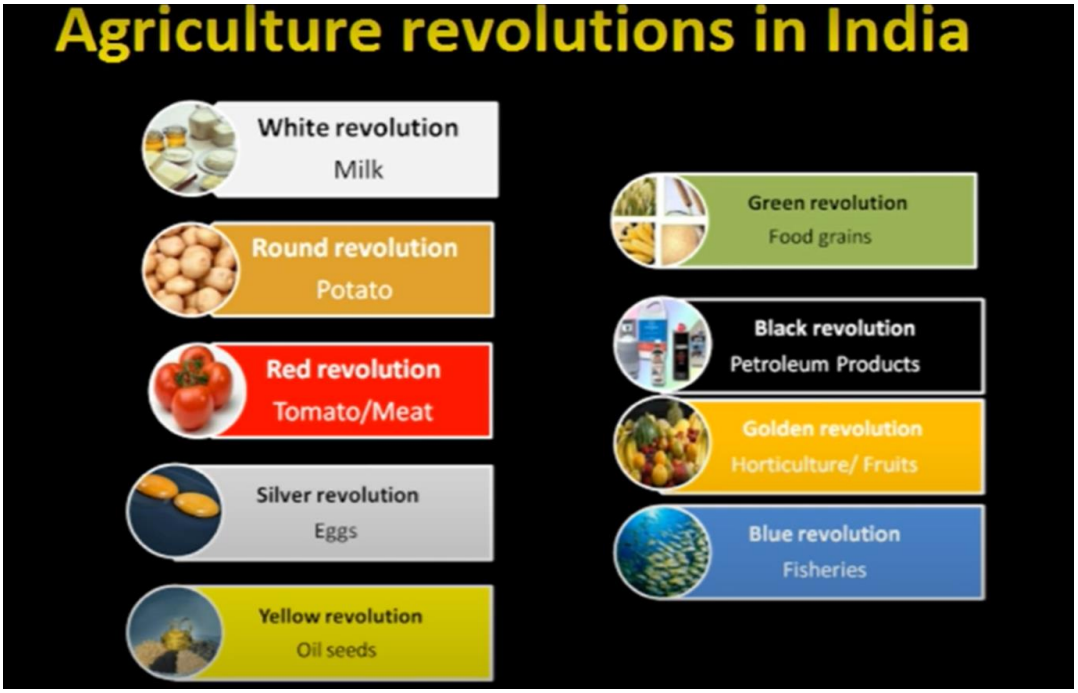

Figure 1: Major Agriculture Revolutions in India

Source: *Author's self-created visuals, Data Source- ICAR Indi*

1.2. Food Grains & Dairy were Key to India's Economic Prosperity

A detailed trend analysis of major food grains including wheat, rice and dairy have shown that since Independence, India have gradually increased the production capacity and productivity of major agricultural commodities, which has led to reduction in foreign imports. Gradually, India also started export of wheat, rice and dairy in other countries of the world. Hence high production and improved productivity level has laid to the path of economic prosperity for the Indian farmers (see Fig 2). However, prosperity driven enhanced consumption has led to lack of self-sufficiency in production yet to be attained for oilseeds. India is still hugely dependent on foreign imports to fulfil the domestic demand of oil consumption. It has also been seen that the edible oils been imported, *does not* guarantee the high-quality standards and higher nutrition levels. The lack of protein is made up by excessive intake of carbohydrates and low quality imported edible oil from foreign countries.

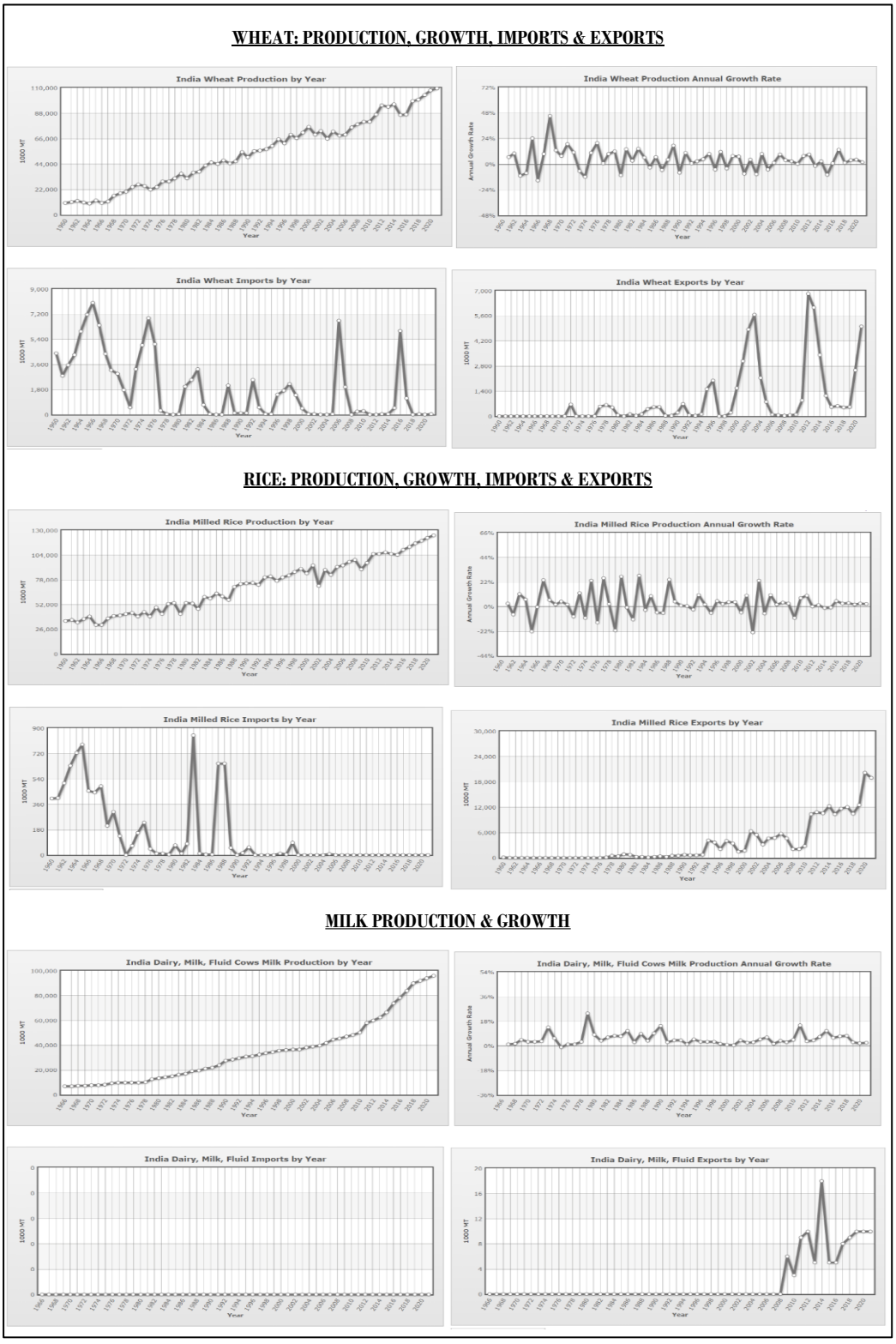

Figure 2: Attainment of Self-Sufficiency in Major Grains & Dairy Products in India Post-Independence

Source: *Author's self-created visuals, Data Source- USDA*

2 LITERATURE REVIEW

Soybean (Glycine max) is one of the world's most important and rapidly expanding oil-bearing crops. Soybean area and production expanded at an annual rate of 2.65% and 4%, respectively, between 1980 and 2013, outpacing the growth in

area and production of most other food crops (calculated by authors from FAO database) [1].

Soybeans cover 37.4 percent of the world's oilseed land and account for 28% of all vegetable oil production. Soybean, a high-value nutritive crop, is important in addressing food and nutritional insecurity, particularly in developing nations. Soybean, a little-known crop until the early 1970s, has risen to prominence in India as an important oilseed crop. Soybean, which is high in protein and edible oil, is now widely recognized as a possible additional source of edible oil and nutritious food all over the world. During the Triennium average Ending (TE) 2012- 13, soybean accounted for 55.6 percent of area under kharif oilseeds and 38 percent of area under total oilseeds in the country. During the comparable period, the crop accounts for 62.5 percent of kharif oilseed output and 47 percent of total oilseed production in the country, as well as 28.6 percent of total vegetable oils and two-thirds of oil meal supplies [2].

Despite being a dominant oilseed crop, yields are significantly below potential and have nearly stagnated in the country at roughly 10-11 qt/ha. In light of the crop's expanding importance, this study attempts to comprehend the growth pattern of soybean yield through time, varietal and yield improvement initiatives, and the resulting impact on socioeconomic development. Soybean productivity in the country was 425 kg/ha in 1970-71, rising to 766 kg/ha in TE 1980-81, and 1297 kg/ha in TE 2012-13, nearly tripling from the previous years. Andhra Pradesh had the highest soybean productivity in the TE 2012-13, with 1719 kg/ha, up from 954 kg/ha in the previous TE 2000-01. Rajasthan, Maharashtra, and Uttarakhand were the other states with higher productivity. When comparing TE 1990 to TE 2000, soybean yield levels in places like Andhra Pradesh, Uttar Pradesh, and Gujarat had decreased [3].

Overall, soybean productivity was increasing, and the rate of yield growth was picking up, thanks to the joint efforts of research, extension, and farmers across the country. In the year 2012-13, the greatest soybean productivity in the country was 1353 kg/ha. From 1980-81 to 2012-13, soybean yields climbed at an annual rate of 1.8 percent per year, with a slower rate of growth in the early decades before picking up in the latter decades. For both researchers and policymakers, temporal changes in crop area and output, as well as variability in crop yield, are key concerns. Soybean yield insecurity was found to be higher in all major soybean-growing states (ranging from 21 to 66%), as well as in India (about 19 per cent). In all soybean-growing states, the trend in soybean yield instability has increased throughout the decades. Because the crop is primarily grown under rain fed circumstances, this could be related to erratic rainfall patterns [4].

The increasing variability in soybean acreage, productivity, and yield is a major source of concern for policymakers [5]. Because of the considerable fall in production levels found in atypical monsoon years, research and extension efforts should be directed toward limiting the influence of abnormal weather circumstances on soybean yield [6]. For both researchers and policymakers, temporal changes in crop area and output, as well as variability in crop yield, are key concerns. Soybean yield insecurity was found to be higher in all major soybean-growing states (ranging from 21 to 66%), as well as in India (about 19 per cent). In all soybean-growing states, the trend in soybean yield instability has increased throughout the decades. This could be attributed to erratic rainfall patterns, as the crop is primarily cultivated in wetland environments. The increasing variability in soybean acreage, productivity, and yield is a major source of concern for policymakers [7].

3 OUTLOOK OF MAJOR OILSEED CROPS IN INDIA

3.1 General Scenario of Oilseed Crops

Major oilseed crops in India basically includes Soya bean, Rapeseed & Mustard, Groundnut, Sesame and Cottonseed. Some minor oilseed crops are Castor seed, Niger seed, Linseed, Safflower and Sunflower. The analysis has shown that in last 10 years the production (in thousand Metric Ton/000 MT.) and area harvested (in thousand Hectare/000 Ha.) has increased just a bit when compared to production growth rates of other food grain. Since year 2010-11 only a slight increment of 10-12% on an average area harvested has been seen in production of most of oilseed crops. *However, the production and productivity of most of the oilseed crops have reduced between 10-30% in past 10 years, raising an alarming concern towards rapidly changing scenario*. This situation might pose a serious threat to National Health and Nutrition Security (see Fig 3).

Specifically talking about Soybean, the average area harvested since year 2010-11 has increased by 12%. However, production and productivity has reduced by 7% & 31% respectively. Major causes of this reduction are lack of processing facilities for Soybean growing farmers, increase in foreign imports, lack of recognition to Non-GMO Indian Soybean at National and International level.

Area Harvested in '000 Ha.

	2019-2020	2018-2019	2017-2018	2016-2017	2015-2016	2014-2015	2013-2014	2012-2013	2011-2012	2010-2011
Groundnut	4825.2	4730.76	4887.7	5338.04	4596.3	4768.65	5504.91	4721.03	5263.74	5856.15
Castorseed	1046.29	751.32	824.13	807.92	1060.73	1089.32	1063.2	1233.59	1470.88	880.34
Nigerseed	136.24	156.46	218.48	256.41	251.67	232.13	298.74	310.41	364.4	371.04
Sesamum	1622.6	1419.97	1579.77	1666.93	1950.88	1746.06	1678.9	1705.76	1901.55	2083.2
Rapeseed & Mustard	6856.27	6123.93	5977.16	6073.82	5745.52	5799.08	6645.74	6362.59	5893.52	6900.48
Linseed	179.9	172.71	326.18	325.22	262.86	285.47	293.07	296.27	322.64	359.23
Safflower	51.79	45.89	82.15	144.27	127.5	174.94	177.73	183.51	250.41	243.85
Sunflower	228.28	262.01	283.51	381.11	486.79	589.76	671.5	830.51	731.86	928.98
Soyabean	12192.71	11131.26	10328.83	11183.4	11604.54	10910.83	11716.43	10840.73	10109.09	9601.04
Cottonseed	13477	12614	12586	10826.4	12292	12819	11960	11977	12178	11235

Production in '000 MT.

	2019-2020	2018-2019	2017-2018	2016-2017	2015-2016	2014-2015	2013-2014	2012-2013	2011-2012	2010-2011
Groundnut	9952.02	6727.18	9252.57	7461.53	6733.33	7401.71	9713.9	4693.88	6963.7	8265.78
Castorseed	1842.02	1196.68	1567.56	1376.42	1751.82	1869.99	1726.55	1963.47	2294.93	1350.32
Nigerseed	41.32	45.42	70.19	85.14	74.27	76.17	97.84	100.83	98.08	107.71
Sesamum	657.5	689.31	755.43	747.03	850.07	827.83	714.58	685.02	810.27	893
Rapeseed & Mustard	9123.64	9255.66	8429.85	7917.23	6796.72	6282.44	7876.65	8028.93	6603.71	8178.71
Linseed	120.66	99.07	173.76	184.25	125.49	154.57	141.73	148.59	152.46	146.54
Safflower	43.67	24.64	55.28	93.9	52.99	90.12	113.37	108.51	145.33	150.43
Sunflower	212.53	216.29	221.66	251.38	296.3	434.2	503.94	544.08	516.64	651.06
Soyabean	11225.85	13267.52	10932.97	13158.73	8569.79	10373.8	11860.84	14666.45	12213.51	12733.7
Cottonseed	36065	28042	32805	32577.41	30005	34805	35902	34220	35200	33000

Productivity in Kg./Ha.

	2019-2020	2018-2019	2017-2018	2016-2017	2015-2016	2014-2015	2013-2014	2012-2013	2011-2012	2010-2011
Groundnut	2063	1422	1893	1398	1465	1552	1765	994	1323	1411
Castorseed	1761	1593	1902	1704	1652	1717	1624	1592	1560	1534
Nigerseed	303	290	321	332	295	328	328	325	269	290
Sesamum	405	485	478	448	436	474	426	402	426	429
Rapeseed & Mustard	1331	1511	1410	1304	1183	1083	1185	1262	1121	1185
Linseed	671	574	533	567	477	541	484	502	473	408
Safflower	843	537	673	651	416	515	638	591	580	617
Sunflower	931	826	782	660	609	736	750	655	706	701
Soyabean	921	1192	1058	1177	738	951	1012	1353	1208	1326
Cottonseed	455	378	443	512	415	462	510	486	491	499

Figure 3: Area, Production & Productivity of Major Oilseed Crops in India

Source: *Author's self-created visuals, Data Source- SOPA DATA BANK, USDA*

3.2 Trend Analysis of Major Oilseed Crops

Trend analysis of edible oil has shown that production of Soybean oil has been reduced in year 2021. This gap has been created due to the effect of Covid-19 pandemic, poor rains and bad weather conditions last year, leading to loss of production of Soybean seed and lesser extraction of Soybean oil. However, the demand of Soybean oil in national and international markets continues to rise exponentially year after year, due to its multiple health benefits and high nutrition value (see Fig 4).

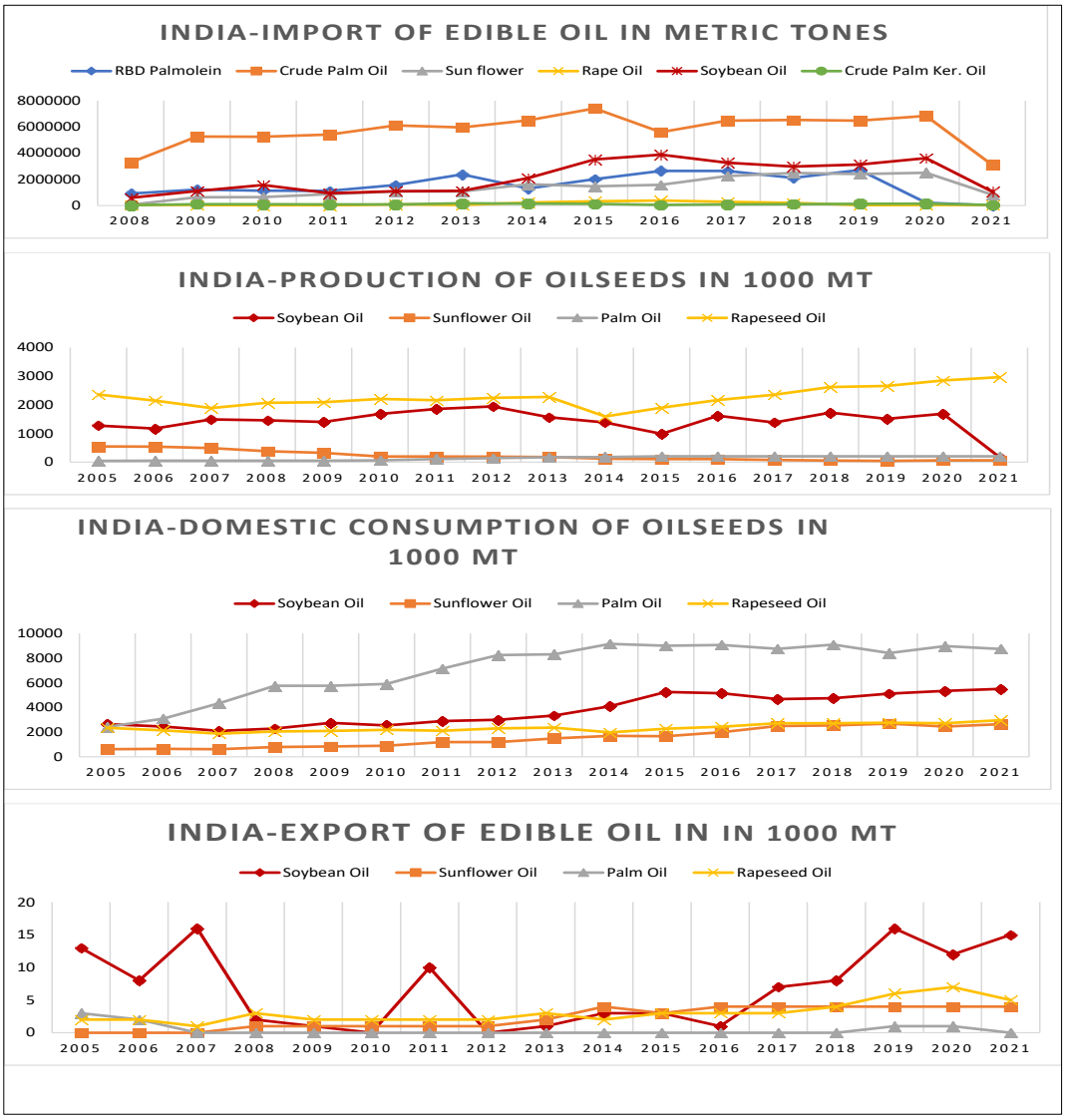

Figure 4: Trend Analysis of Edible Oil Produced from Oilseed Crops

Source: *Author's self-created visuals, Data Source- SOPA DATA BANK, USDA*

Trend analysis of meal cakes has shown that import of Soybean meal cakes (after the bean has been crushed) has increased tremendously since year 2019-2020. Some part of meal imported last year was basically GMO in nature and its health implications or side effects on animal and poultry health are still unknown. The domestic consumption of Soybean meal cakes also increased at faster pace of 10.59 % since last year due to its huge demand in poultry segment. However, the rate of meal production has only increased by 5.31 % since last year, which indicates requirement to more soybean processing units, to fulfil the growing domestic demand (see Figure 5).

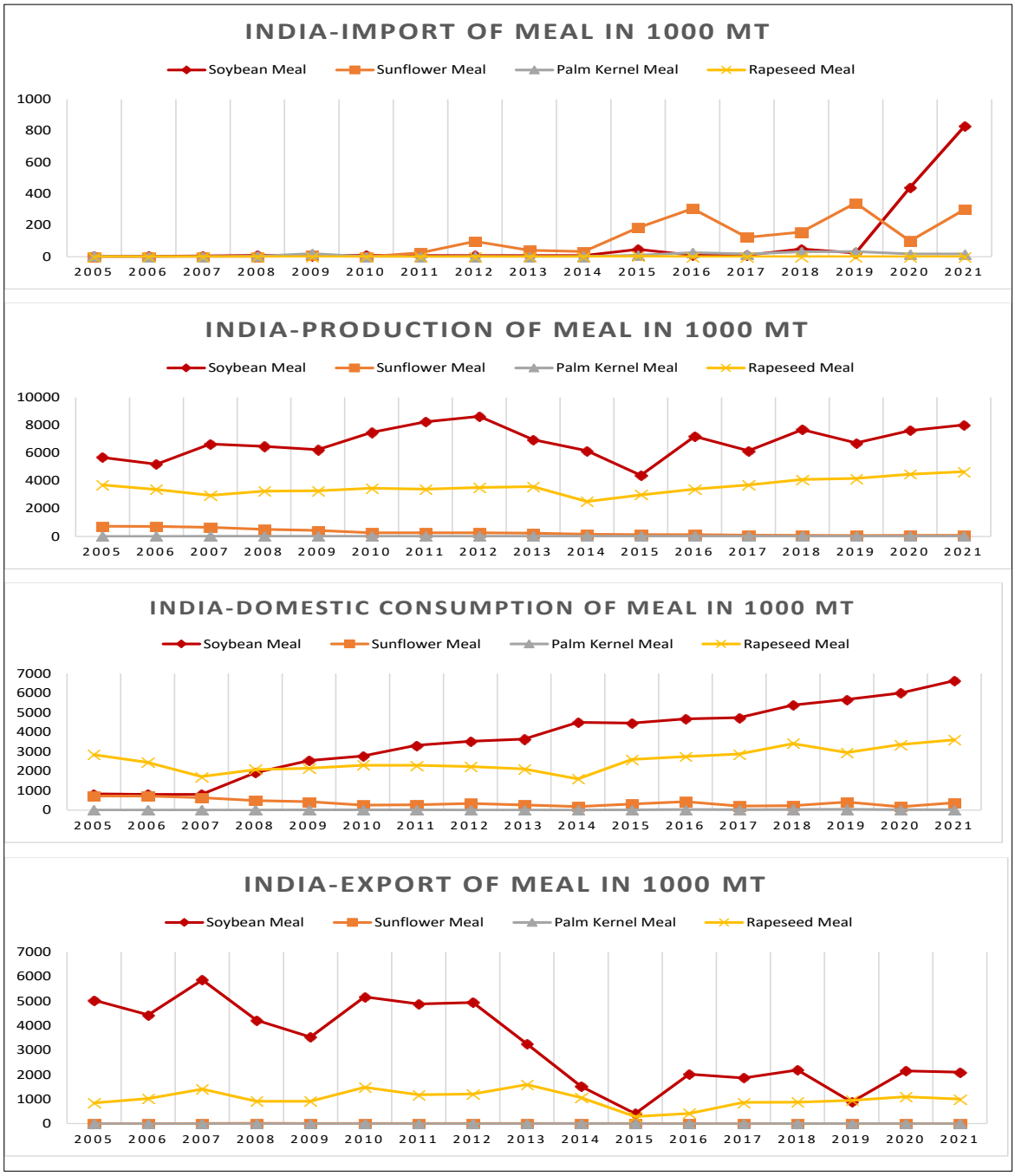

Figure 5: Trend Analysis of Meal Cakes Produced from Oilseed Crops

Source: *Author's self-created visuals, Data Source- SOPA DATA BANK, USDA*

4 SPECIAL FOCUS ON NON-GMO SOYBEAN: A HOPE OF INDIAN FARMERS FOR A PROSPEROUS FUTURE

4.1 Soybean: Origin and Applications

Soybean (*Glycine max*), otherwise known as a 'miracle crop' or 'wonder crop' with over 40% protein and 20% oil, originated in China. It was introduced to India centuries ago through the Himalayan routes by traders from Indonesia. To deal with the country's perennial protein malnutrition due to the stagnant pulse production, dedicated efforts were initiated in the mid-1960s by the G B Pant University of Agriculture and Technology (GBPUAT), Pantnagar (Uttaranchal) and the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh), in collaboration with the University of Illinois,

USA to popularize soybean cultivation in India. Through the well-coordinated efforts, soybean has now become an important crop in India.

Soybean is an excellent source of high-quality protein, is low content in saturated fat, contains dietary fibre and its is oflavone content makes it best among other legumes. Soybean protein helps in prevention against cardiovascular disease, osteoporosis, cancers, endometrium, and prostate. It is considered as the replacement of animal-based foods, in order to obtain some nutritional benefits. It is found in many foods including milk, tofu, and processed foods like soybean oil, soya-breads and cereals. Soy is most commonly eaten as a plant protein as it has all the amino acids that act as the building blocks of protein. It is also considered a good source of calcium, fibre, potassium, magnesium, copper, manganese, and polyunsaturated fats like omega-3 and omega-6. In addition to whole foods, soy is available in supplement form including health drink, tablets and powders (see Figure 6).

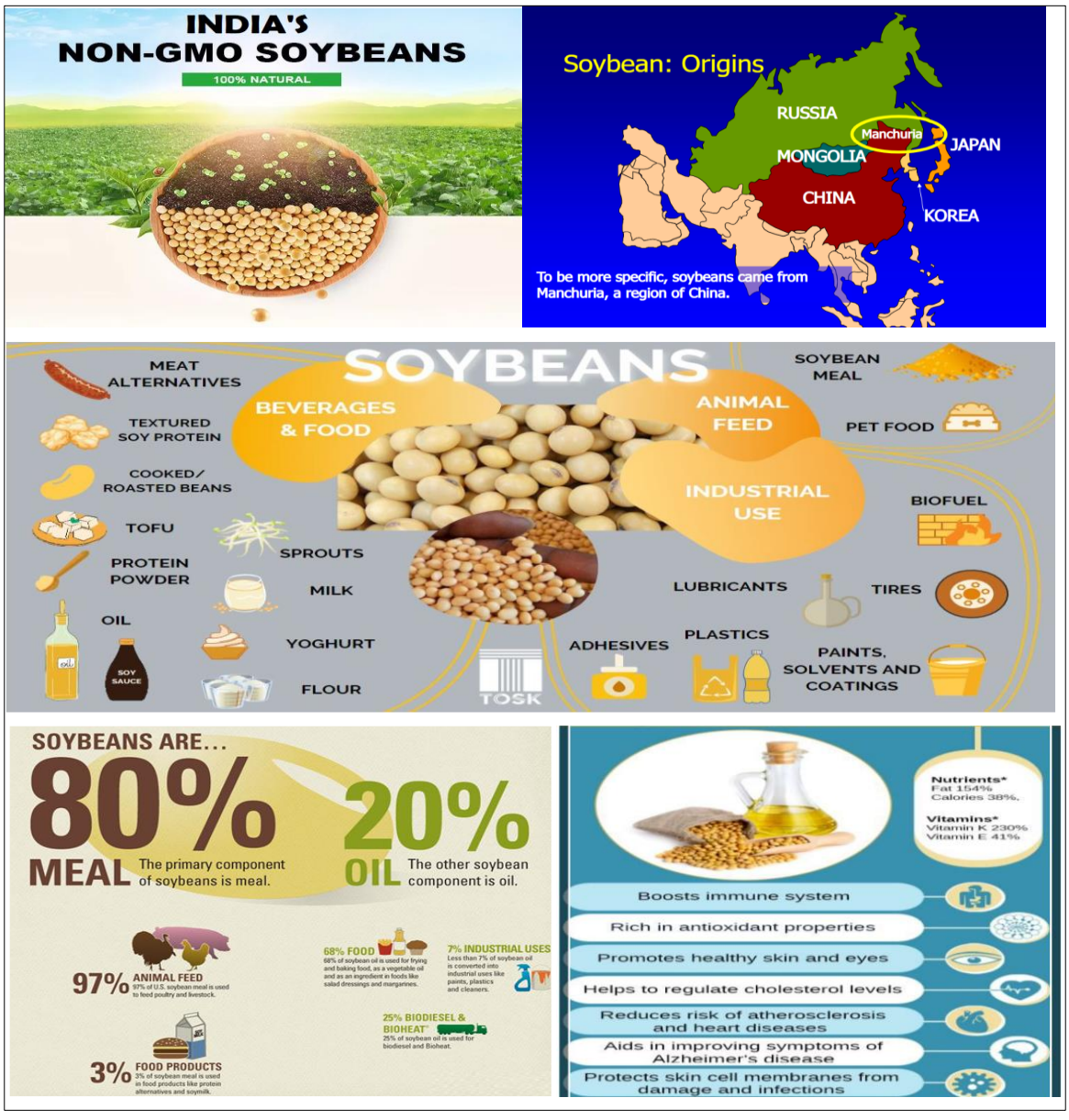

Figure 6: Non-GMO Soybean: A Wonder Crop

Source: *Author's self-created visuals, Data Source- USDA, https://www.verifiedmarketresearch.com/, U.S. Soybean Export Council*

4.2 Global Non-GMO Soybean Market

The Global Non-GMO Soybean market is expected to rise at a Compound Annual Growth Rate (CAGR) of 8.30% from 2018 to 2022 (as investigated by *verifiedmarketresearch*). According to Verified Market Research, the Global Non-GMO Soybean Market was valued at 73.07 Million Metric Tons in 2018 and is projected to reach 99.80 Million Metric Tons by 2022. Soybeans serve a variety of functions in the global food chain, ranging from use as edible oil to a source of protein for humans to use in livestock feed. Globally, approximately 87 percent of all soybean production is crushed into soy meal and soy oil, with the remaining 13 percent used for direct human consumption. From the soybean crushing process, roughly 80 per cent is extracted as soy meal for use in animal feed and 20 per cent is extracted as oil for human consumption and as a biofuel feedstock.

GMO is an acronym that stands for genetically modified organisms. A GMO is a food product that has been changed in some way on the genetic level. Most developed nations do not consider GMOs to be safe. In more than 60 countries around the world, including Australia, Japan, and all of the countries in the European Union, there are significant restrictions or outright bans on the production and sale of GMOs. There are many health and environmental risks with genetically modified (GM) Soybean. As a result of these risks, worldwide people are demanding non-genetically modified (NON-GMO) Soybean. Asia-Pacific is the largest market, with a share about 55%, followed by Europe, and North America, both have a share over 35 percent. In terms of product, Plain Non-GM Soybeans is the largest segment, with a share over 45%. In terms of application, the largest application is Human Consumption, followed by Animal Feed, etc. According to GII Research Agency, the global Non-GMO Soybean market is valued at US$ 53040 million in 2020. The market size will reach US$ 69110 million by the end of 2027, growing at a CAGR of 2.5% during 2021-2027.

The United States, which is the world's second-leading soybean producer, is now the biggest importer of India's non-GMO soybean meal. Indian soymeal is given priority in the U.S. since it needs non-GM soybean. Hardly five percent of the soybean crop in the U.S. is non-GMO, and those who want non-GMO soy products there have to pay a premium. That way, the Indian soymeal is competitive. India is the largest importer of soybean oil in the world. An expected tighter supply has also forced India, that usually exports soymeal, to import in year 2021. For year 2021-22, India's soybean oil imports are projected at about 3.3 million MT. India's marketing year for edible oil trade runs from November through October. Over the past few years, India's soybean oil imports have seen a gradual increase on account of rising domestic soybean production. Apart from the likely increase in soybean oil imports, India's soymeal sector could also face trade challenges.

Recently, the Indian government has allowed import of about 1.2 million MT of genetically modified soymeal for poultry consumption due to existing supply shortfall. India, that usually exports soymeal, has turned to imports amid soaring prices. Trade experts believe that the lower soybean crop production and high international prices of soybeans would result in India importing soybean meal in the next few years as well.

Non-GMO Soybean is now attracting a lot of attention owing to growing consumer dissent against GM Soybean. The rising consumer awareness regarding labelling regulations and the quality of products is expected to drive market demand over the forecast period. The premiums for non-GMO soybean have also seen exponential growth rates owing to which the market is expected to grow at a rapid pace.

Major Factors Influencing the Non-GMO Soybean Market (see Figure 7) are mentioned below:

Favourable Regulations and consumer Sentiment Regarding Non-GMO Soybean

Regulations play an important role in driving market demand for non-GMO soybean. The introduction of GMO Soybean brought about a revolution in the market owing to which regulatory agencies brought about regulations to ensure that these products cause no harm to human health. Although the adoption of GMO Soybean is increasing, the growing consumer dissent regarding the side effects of GMO crops is expected to have a positive impact on market demand for non-GMO soybean.

Involvement of Small Scale Suppliers

Soybean cultivation is increasing gradually and the high margins offered by the soybean products have attracted a large number of industry participants. Few farmers who were previously focused on soybean cultivation are now turning towards soybean processing to manufacture products such as soybean meal, soybean oil, and livestock feed.

GMO labelling

The demand for non-GMO protein, in particular, is moving on an upward spiral, as it encompasses overarching trends such as clean label (without GMO residue), plant-based protein, and sustainability. Moreover, aversion of consumers to artificial products is emerging as a key growth factor for the non-GMO soy protein market.

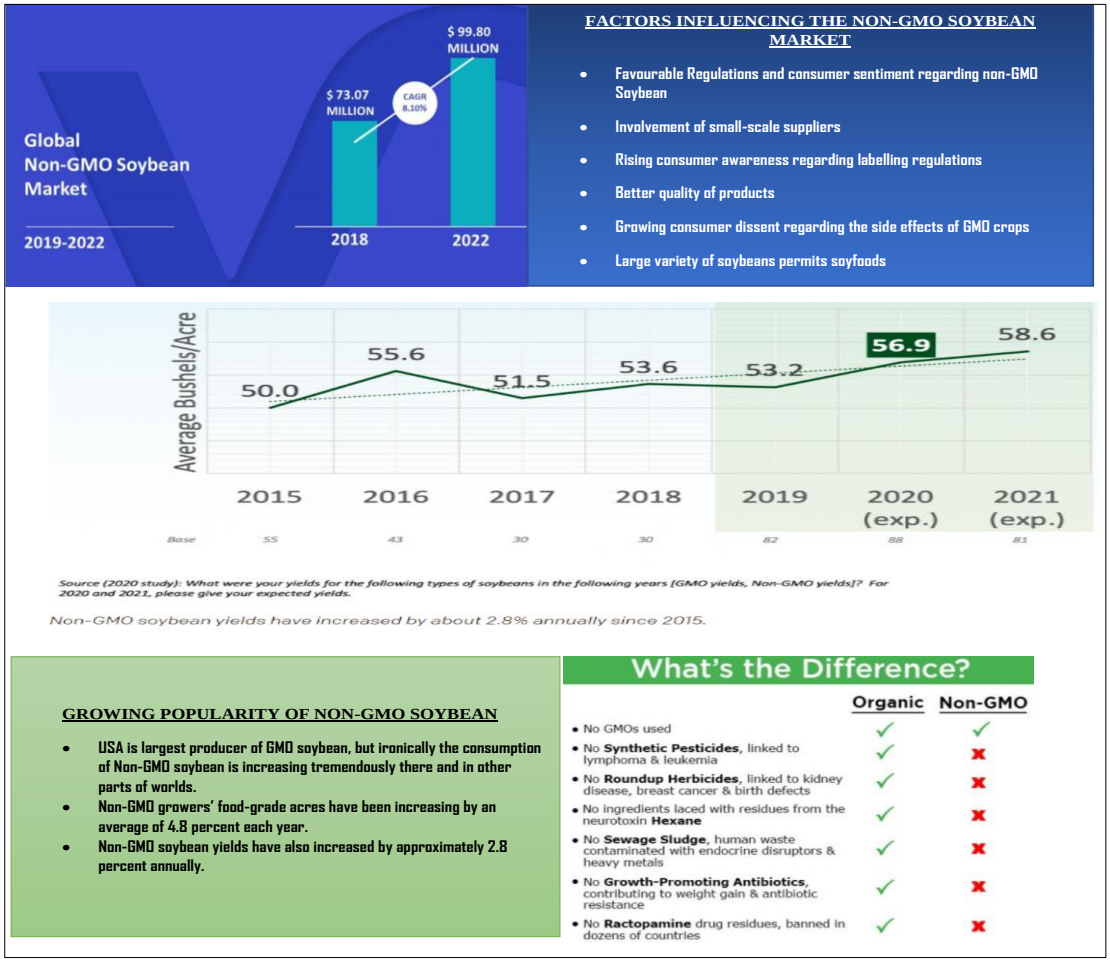

Figure 7: Global Trend Analysis of Non-GMO Soybean

Source: *Author's self-created visuals, Data Source- USDA, https://www.verifiedmarketresearch.com/, U.S. Soybean Export Council*

5 MADHYA PRADESH STRIVING TO MAINTAIN IT'S SUPREMACY IN NATIONAL AND INTERNATIONAL SOYBEAN MARKETS

Madhya Pradesh is known as the "Soybean State" of India, comprising 55% of the total national area of soybean cultivation. The Malwa region of Madhya Pradesh is one of best regions for growing Soybean due its soil and climatic conditions. Crop could grow well in the region's black cotton soil and didn't require much effort. Between 2002-03 and 2013-14, the value of soya-meal shipments from India soared from just over Rs 1,360 crore to almost Rs 14,500 crore. As the fortunes of the industry rose — realisations from oil, too, went up — so did that of soyabean growers in Malwa and the neighbouring regions of MP. During this period, the average price of soyabean in Indore market climbed from Rs 1,353 to Rs 3,667 per quintal.That boom collapsed after 2013-14, along with a crash in global agri-commodity prices.In 2021, Soyabean prices have crashed by close to 50% within a month in Madhya Pradesh and Maharashtra, the top soyabean producing states of the country leading to farmers' protests across the soyabean growing states.After a historical high of Rs 95/kg, prices have crashed to Rs 60-55/kg, depending upon the quality. India allowed import of 12 lakh tonnes of genetically modified soyameal in August, which led to fall in prices of soyabean at a time when farmers have started harvesting the kharif crop.The country's poultry industry had demanded import of 1.2 million tonnes of genetically modified soyameal, as the historically-high prices had increased costs for poultry farmers and forced some out of business.

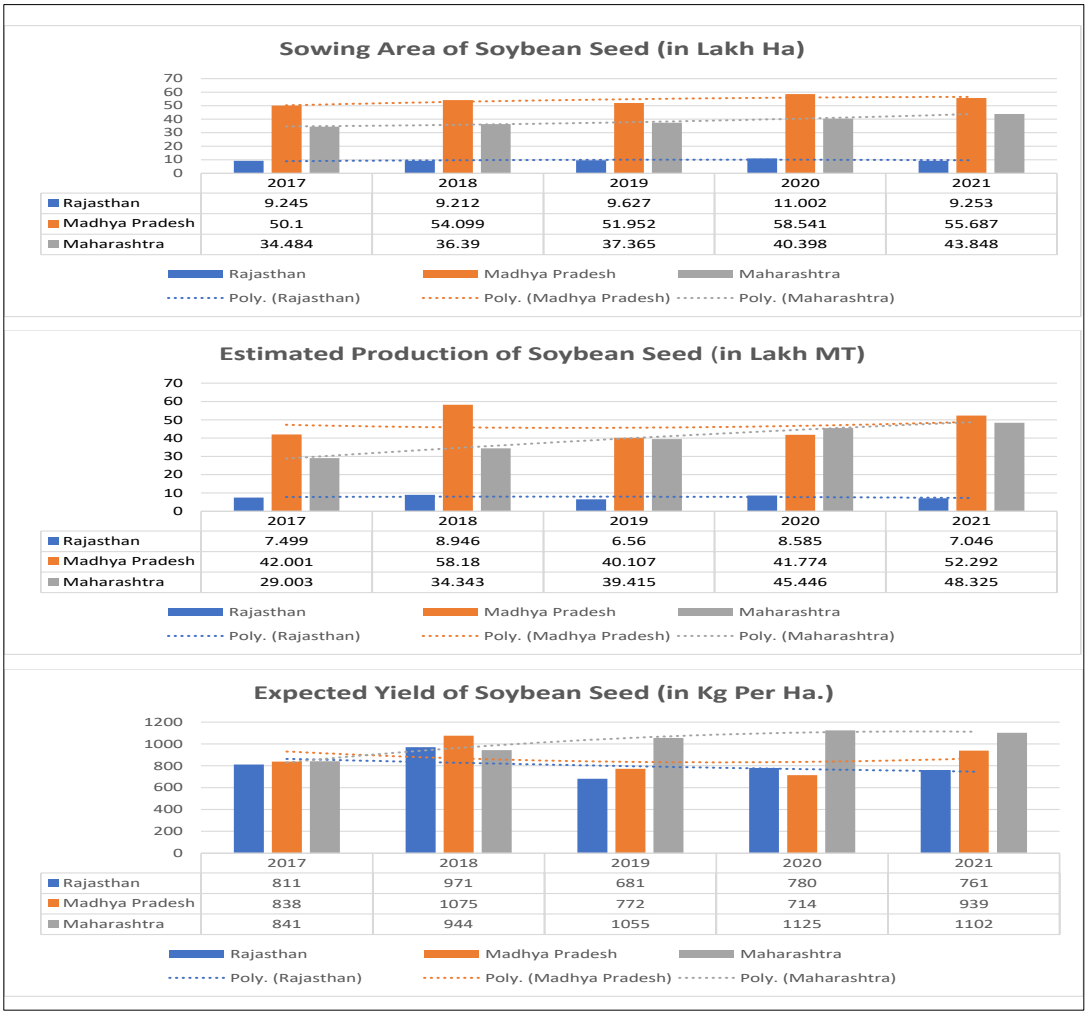

Figure 8: Scenario Analysis of Soybean in Top 3 Producing States

Source: *Author's self-created visuals, Data Source- SOPA DATA BANK*

According to India's ministry of agriculture, planted area under soybean was at 12.2 million hectares in 2021-22, slightly higher than 12.1 million hectares in 2020-21.However, the area in Madhya Pradesh, India's primary soybean growing state, the planted area was nearly 5% lower on the year at 5.6 million hectares (See Fig 8). Madhya Pradesh usually produces 6.5 million MT of soybeans in a year. Gradually farmers are shifting towards other oilseed crops.

There is an urgent need of government intervention to safeguard the interest of Soybean growing farmers and soybean processors. It could be only done by promoting the Non-GMO Indian Soybean in national and international markets, reducing the imports of soymeal (to motivate indigenous soybean processors) and increasing the import duties on soymeal and soyoil to boost the local processors and industries.

CONCLUSIONS

Government involvement is urgently needed to protect the interests of soybean growers and processors. It could only be done by promoting non-GMO Indian soybeans in national and international markets, lowering soymeal imports (to encourage indigenous soybean processors), and raising import tariffs on soymeal and soyoil to help local processors and industries.

REFERENCES

1. *Riaz, M. N. (2006). Processing of soybeans into ingredients. Soy applications in food,40-62.*
2. *https://www.fas.usda.gov/commodities/soybeans. Data retrieved on12-05-2021.*
3. *https://www.feedipedia.org/node/674. Data retrieved on12-05-2021.*
4. *https://www.drycargomag.com/global-soybean-market-faces-challenge-to-adapt-in-2020. Data retrieved on12-05-2021.*
5. *Agarwal, D. K., Billore, S. D., Sharma, A. N., Dupare, B. U., & Srivastava, S. K. (2013). Soybean: introduction, improvement, and utilization in India—problems and prospects. Agricultural Research, 2(4), 293-300.*
6. *Sharma, P., Dupare, B. U., & Patel, R. M. (2016). Soybean improvement through research in India and socio-economic changes. Legume Research: An International Journal, 39(6).*
7. *Chatterjee, T., Raghunathan, R., & Gulati, A. (2020). 18 Agri-commodity futures and value chains. Transforming Agriculture in South Asia: The Role of Value Chains and Contract Farming, 317.*
8. *Kumar, N. K. H., and Jagannath Shobha. "Assessment of herbicide alachlor impact on seed germination and seedling related traits of soybean (JS-9305, DSB-21 and JS-335) seedlings." International Journal of Agricultural Science and Research (IJASR) 5.5 (2015): 109-116.*
9. *Vijayakumar, H. P., and A. Vijayakumar. "Standardization of accelerated ageing duration to evaluate seed storability of soybean cultivars." International Journal of Agricultural Science and Research (IJASR) 5.4 (2015): 93-98.*
10. *Singh, S. K., et al. "Symbiotic effectiveness of genetically marked phage resistant mutants of soybean (Glycine max Merrill) bradyrhizobial strains." International Journal of Agricultural Science and Research (IJASR) 3.1 (2013): 121-128.*
11. *Ukpe, Emmanuel., and S. M. F. D. S. Mustapha. "Agricultural knowledge management: a case study of Nigeria cassava production process." Journal of Agricultural Science and Research 3 (2016): 11-16.*